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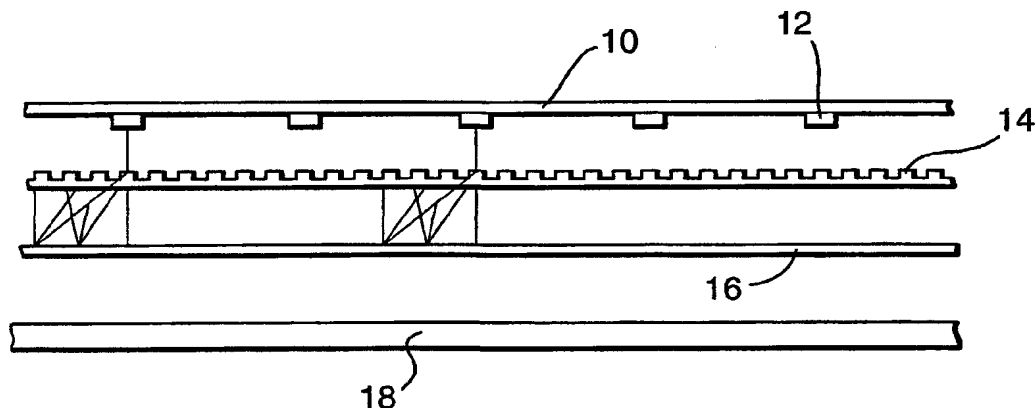
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(54) Title: DIFFUSE LIGHTING ARRANGEMENT



(57) Abstract: A diffuse lighting arrangement, for example for backlighting an LCD display, comprises a two dimensional array of individual localised light sources, such as light emitting diodes (12) and at least one two dimensional grating (14) spaced in front of that array. A light diffusing plate or sheet (16) is preferably disposed in front of the diffraction grating (14).



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Title: " Diffuse Lighting Arrangement"

THIS INVENTION relates to an arrangement for providing a diffuse light source, for example, as a back-lighting arrangement for LCD displays, such as are utilised in portable computers.

Conventionally, back-lighting arrangements for LCD displays in portable computers and the like have comprised edge-lit reflector blocks, generally edge-lit by a linear light source such as a fluorescent tube, the reflector blocks being configured internally so that light entering the block from the source along one edge is reflected by reflective surfaces bounding the block and/or by total internal reflection at angled surfaces contrived within the block, to emerge from a front face of the block at various locations on that front face and along various exit paths. An alternative back-lighting arrangement which has been used in the past comprises a cold-cathode fluorescent tube in a sinuous shape to provide an array of laterally parallel bars, interconnected by bends, backed by a reflector. In either case, a diffuser is normally disposed in front of the edge-lit reflector block or the sinuous discharge tube in an attempt to provide as far as possible an evenly light-emitting source with no perceptible "hot spots". The diffusers required in either case must generally have a strong diffusive effect to avoid perception of the shape and configuration of the underlying light source or reflector arrangement, and consequently most of the light passing through the diffuser passes in directions too far removed from the normal viewing angle

to serve usefully to illuminate the display. (With a view to increasing the amount of light which is at least initially directed normal to the plane of the display, it is known to interpose one or more layers of prismatic transparent plastics films, (also referred to as brightness-enhancing films) between the diffuser and the remainder of the back-lighting arrangement, but this expedient besides being less than wholly successful, also adds to the size (i.e. depth) of the display, to manufacturing complexity and, albeit to a minor extent, to the weight of the apparatus). These prior back-lighting arrangements are thus relatively inefficient in terms of energy usage, which is a significant consideration with battery-powered apparatus such as portable computers, and additionally tend to generate unwanted heat. The light sources, such as cold-cathode fluorescent discharge tubes, used in such prior displays, may also require high voltages, requiring complex additional electrical circuitry, resulting in further energy inefficiency and added weight and manufacturing costs.

Coloured LEDs (light emitting diodes) have been available for several years. However, white LEDs have been created and are now commercially available with increasing brightness and lower cost such that they are now considered cost effective when compared with incandescent and fluorescent sources of similar brightness. LEDs have the added advantage of low operating voltage.

In accordance with one aspect of the present invention, it is proposed to use, as a diffuse light source suitable for back-illumination of LCD displays and like applications, an array of light-emitting diodes (LEDs) to afford an efficient means of generating light with low voltages such as those generally available in and utilised by portable computers and the like and without significant heat generation, etc.

Thus, in accordance with the present invention, there is provided an LCD display which is back-lit by a lighting arrangement utilising one or more light-emitting diodes (LEDs) as a light source.

In an alternative embodiment of the present invention, there is provided a lighting arrangement comprising one or more LEDs as a light source suitable for domestic or commercial lighting or as a light box for the detailed examination of light transparent images such as X-ray photographs.

In order to provide uniform lighting, i.e. so that perception of individual LEDs does not intrude upon perception of the display, some additional measure is required unless the LEDs are to be so numerous and closely packed as to present, visually, a continuous illuminated surface. Given the effectiveness, or lack of it, of conventional diffusers, merely placing such a conventional diffuser in front of an array of even a moderate number of LEDs does not allow the desired uniformity of illumination to be achieved without significant loss of brightness.

It is a further object of the present invention in a preferred embodiment to provide a means whereby a uniform illumination can be provided by an array of a relatively few LEDs.

According to another aspect of the invention, therefore, there is provided a diffusive lighting arrangement comprising at least one localised light source, at least one diffraction grating spaced in front of said light source and at least one diffuser spaced in front of the diffraction grating.

The diffused lighting arrangement may, for example, be a back-lighting arrangement for an LCD display or the like.

The effect of the diffraction grating, as described in more detail later, is to create from a single or point light source such as a laser, pixel or LED a diffracted light pattern comprising zero, first and subsequent orders. However, when a multi wavelength or "white" light source is used, the grating will also tend to split the light into the primary colours. Although the primary use of the diffuser is to produce a more uniform light source, a secondary function is to combine colours from separate coloured LEDs or recombine the light from white LEDs such that the lighting arrangement exhibits both uniform colour and brightness.

An embodiment of the invention is described below by way of example with reference to the accompanying drawings in which:-

FIGURE 1 is a schematic perspective exploded view illustrating a back-lighting arrangement in accordance with the invention applied to an LCD display, for example of a portable computer,

FIGURE 2 is a schematic cross sectional view of such a display, and

FIGURE 3 is a schematic cross-sectional view illustrating the effect of the diffraction grating in an arrangement in accordance with the invention.

Referring to Figures 1 and 2, reference 10 represents a back plane, which may, for example, simply be a rear wall of a display structure supporting an array of light-emitting diodes (LEDs) 12, the array comprising rows and columns of LEDs 12. The LEDs 12 have, of course, conductors which are connected in manner known *per se* with an electrical power supply (not shown). The back plane or support 10 preferably has a reflective coating on its front surface, (i.e.

on the side on which the LEDs are exposed) to ensure that any light emitted or scattered in the rearward direction is reflected forwards towards the LCD cell (see below). The back plane 10 may, for example, comprise a printed circuit board on which the LEDs are soldered and which connects the LEDs to a power supply. The reflecting coating may be applied to the front of that printed circuit board or may be provided by a separate reflective sheet mounted slightly in front of the printed circuit board and having apertures to receive the LEDs.

By way of example, the individual LEDs may have a light-emitting area of around 2 mm squared and may be arranged 5 to 10 mm apart.

Located in front of the array of LEDs 12, and extending parallel with the latter and thus with the back plane 10, is a two-dimensional light diffracting sheet 14 which for convenience will be referred to hereafter as a diffraction grating. The grating 14 may indeed simply be a sheet of glass or transparent plastics having a surface on which is formed by a rectangular grid comprising two sets of mutually perpendicular grid lines, scored, etched or impressed upon such surface. However, it is preferred to use a diffracting sheet 14 such as described in GB-2314943 comprising a plastics sheet having on one surface thereof a regular array of upstanding cylinders, conical frustums or other geometrical features taking advantage of the possibility afforded for tailoring the relative intensities of the different diffraction orders, for example, by appropriate design of the individual upstanding features. Typically, the individual cylinders or like features in such a diffracting sheet may be  $25\mu$  in height and diameter and spaced  $40\mu$  apart. Such diffraction sheets or gratings may be readily produced by embossing plastics for example. (As described in GB-2314943, the relief features may be covered or the regions between features filled, by a medium of different refractive index to afford a diffracting sheet smooth on both sides). Disposed in front of the grating 14, spaced therefrom

and parallel therewith, is a diffusing screen 16, which may be of conventional form or may be of the kind disclosed, for example, in European Patent Application No. 0294122 and comprising an array of minute graded refractive index lenses or like optical features. Finally, a conventional LCD cell structure 18, (represented in Figure 2 as a single sheet since the structure of such cells is well known), is spaced in front of the diffuser 16 and again is arranged parallel with the back plane 10, sheet 14, and diffuser 16. It will be appreciated that where the display is intended for a portable computer or the like, the LCD cell 18 comprises an array of individually activatable elements providing respective "pixels" of a display.

Referring to Figure 3, and assuming, for simplicity, the light from a single LED 12 of the array to be monochromatic and coherent, a given beam from the LED 12 to a given point, A, on the diffraction grating 14 will be diffracted by the latter to form, in addition to a zero order beam  $I_0$ , transmitted through the grating, first, second, third, etc. order beams  $I_1$ ,  $I_2$ ,  $I_3$  etc. as illustrated, diverging from the grating at different angles. Because of the two-dimensional nature of the diffraction grating 14, the beam I will be diffracted into first, second, third, etc. order beams not only in a plane perpendicular to the plane of the grating and to a first set of parallel grating lines, but also in a perpendicular plane, also perpendicular to the plane of the grating, parallel to the second set of grating lines, and additionally into beams in various other planes perpendicular to the plane of the grating and thus will give rise to a relatively complex bundle of diffracted rays emerging from the grating 14 towards the diffuser 16. A corresponding effect is provided, of course, on each ray passing from the LED 12 to any other point on the diffraction grating 14 (e.g. point B) and thus at corresponding different angles. Corresponding effects are, of course, provided by each of the LEDs, with the result that, from the perspective of the diffuser 16, the diffraction grating 14 acts as an array of a very large

number of individual light sources. The effect is in some ways analogous to the effect of a random diffuser, but because of the organised and "tailored" nature of the grating 14, the "spread" of light from each LED after diffraction by grating 14, can be engineered to be predominantly in the desired direction towards the LCD cell. The grating 14 is thus more efficient than and provides more uniform illumination than would a conventional diffuser. By way of example by appropriate detailed design of the diffraction grating, it is possible to arrange matters so that, for example, the intensity of the first-order diffracted beams is substantially the same as that of the zero order beam transmitted through the grating whilst the intensity of high order diffracted beams is significantly reduced. By such design techniques, and appropriate selection of the spacing between the diffraction grating and the LED array, it is possible in effect to multiply the number of light sources and reduce their spacing, from a point of view in front of the grating, and to approach the ideal of an infinite number of uniformly arranged light sources, of the same intensity spaced apart infinitesimally. It will be understood that, in principle, the more light sources per unit area of the back-lighting array, the less powerful (i.e. less strongly diffusive) need be the diffuser to achieve uniformity of illumination, and the more efficient the back-lighting arrangement becomes in directing light forwardly into the region from which the display is likely to be viewed. The diffraction grating or gratings 14 may take any of many different forms. GB2314943 describes various diffraction gratings or diffraction arrays which may be formed for example, by embossing plastics, and which are described in GB2314943 as being of use as depixelators. Both planar and surface relief diffracting arrays are disclosed. These devices are based on diffracting substructures which create first and second order diffracted sources from a single point source. The detailed design determines the relative strength of the primary first and second orders.

The diffuser 16 serves to disperse only slightly the diffracted rays striking it from the diffraction grating 14, with the result that, from the perspective of the LCD cell 18, the diffuser 16 is effectively a uniform diffusive light source. The diffuser 16 is preferably a relatively weak "random" diffuser and thus has little or no tendency to absorb light or scatter it back unduly.

It will be appreciated that it is normally desirable that the LCD screen should be illuminated by white light rather than by monochromatic light. To this end, the LEDs 12 may comprise red, green and blue LEDs interspersed with one another on the supporting plane 10. However, more preferably, the LEDs 12 may be white light LEDs of the sort which have recently become available.

It will be understood that, depending upon the number and size of LEDs available, two or more gratings 14 may be provided, one spaced in front of the other, instead of the single grating 14. In this case, of course, different such gratings may comprise each a single set of mutually parallel grid lines, with the grid lines of each grating being perpendicular to or at a selected different angle to the grid lines of the other grating or gratings. Likewise several random diffusers may be provided instead of the diffuser 16 or one diffuser may be interposed between two gratings 14, according to the properties desired.

In the present specification "comprise" means "includes or consists of" and "comprising" means "including or consisting of".

The features disclosed in the foregoing description, or the following claims, or the accompanying drawings, expressed in their specific forms or in terms of a means for performing the disclosed function, or a method or process for attaining the disclosed result, as appropriate, may, separately, or in any

combination of such features, be utilised for realising the invention in diverse forms thereof.

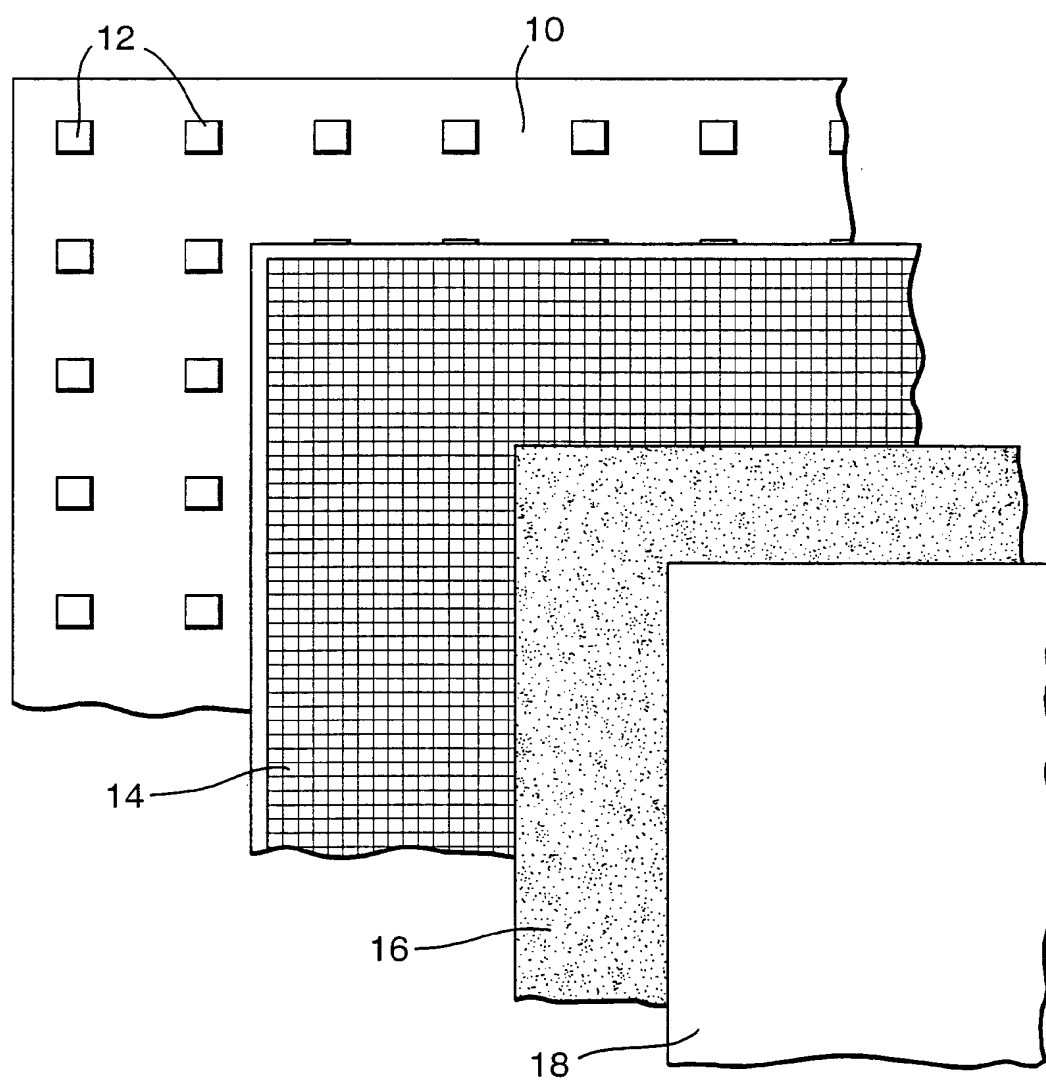
## CLAIMS

1. A diffusive lighting arrangement comprising at least one localised light source and at least one diffraction grating spaced in front of the light source.
2. A diffusive lighting arrangement according to claim 1, including at least one diffuser spaced in front of the diffraction grating.
3. A diffuse lighting arrangement comprising a two dimensional array of localised light sources, at least one two-dimensional diffraction grating spaced from said array and in front of the latter, and at least one diffuser disposed in front of said diffraction grating.
4. A back-lighting arrangement suitable for an LCD display, the back-lighting arrangement comprising at least one localised light source, at least one diffraction grating spaced in front of said light source and at least one diffuser spaced in front of the diffraction grating.
5. A back-lighting arrangement suitable for an LCD display, the back-lighting arrangement comprising a two-dimensional array of localised light sources, at least one two-dimensional diffraction grating spaced from said array and in front of the latter, and at least one diffuser disposed in front of said diffraction grating and spaced therefrom.
6. An arrangement according to any of claims 1 to 4 wherein the or each said localised light source comprises a light-emitting diode (LED).

7. An arrangement according to any preceding claim including a second diffraction grating spaced in front of the first-mentioned diffraction grating.
8. An arrangement according to claim 6 wherein the or each said localised light source comprises a white-light light-emitting diode (LED).

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Fig.1.



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Fig.2.

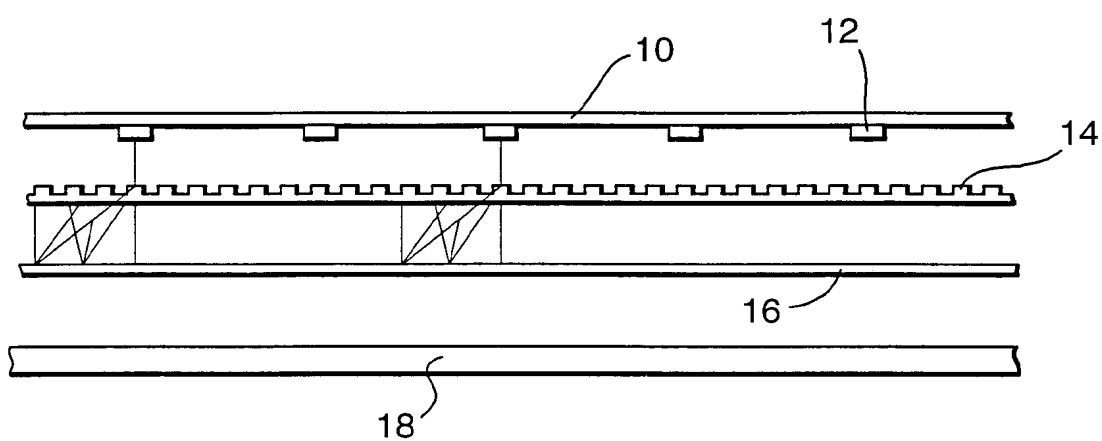
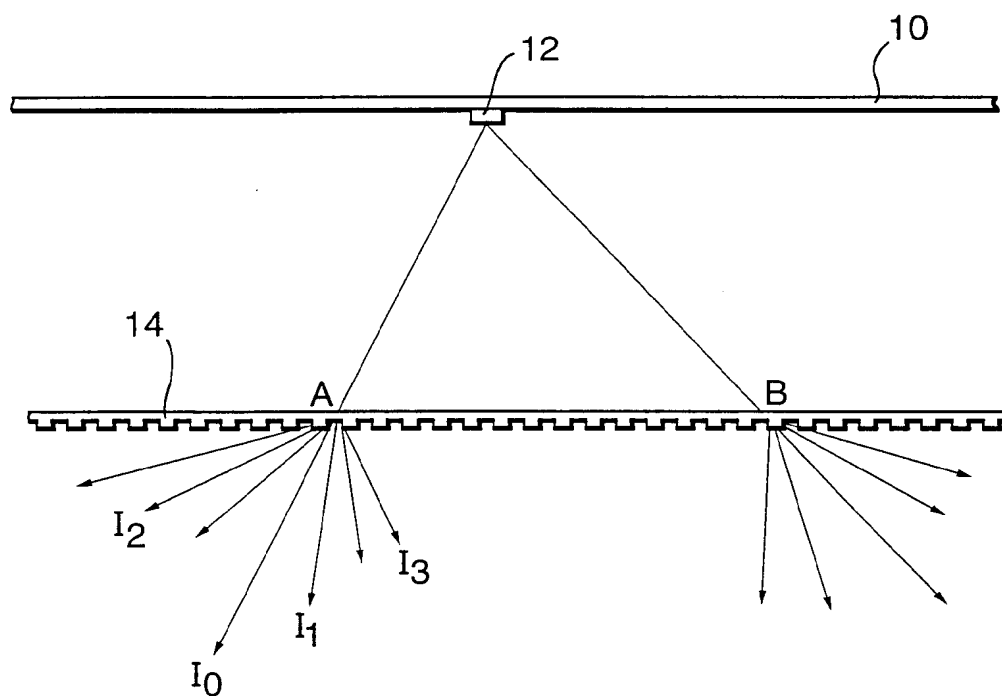


Fig.3.



# INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 00/03177

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F21V5/02 //F21Y101:02,F21W131:30

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 F21V F21S G02F F21K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 803 579 A (TURNBULL ROBERT R ET AL) 8 September 1998 (1998-09-08) column 1, line 5 - line 9 column 9, line 62 -column 10, line 12 column 10, line 59 -column 11, line 25 column 12, line 44 - line 60 column 13, line 18 - line 29 column 13, line 49 -column 14, line 41 figures 1,2	1,2,6
A	----	3-5,7
P,X	EP 1 016 817 A (NOKIA MOBILE PHONES LTD) 5 July 2000 (2000-07-05) column 6, line 31 -column 7, line 8 column 10, line 44 - line 51 column 11, line 20 - line 25 figures 1A,3A,8,9A,9B	1,6
P,A	----	3-5
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☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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# INTERNATIONAL SEARCH REPORT

International Application No

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	<p>EP 0 704 655 A (CARELLO SPA)  3 April 1996 (1996-04-03)  column 1, line 3 - line 9  column 3, line 28 - line 41  column 4, line 38 - line 57  column 5, line 41 -column 6, line 55  figures 1,2,4,5,8,9,13,14</p>	1,3-7
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